CYTOTAXONOMY OF CIRSIUM MUTICUM, CIRSIUM DISCOLOR, AND CIRSIUM ALTISSIMUM[1]

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Abstract

Morphological descriptions, chromosome numbers, and Canadian distribution of *Cirsium muticum* and *C. discolor* are given. The related species *C. altissimum* of the United States is similarly considered. The chromosome numbers of the species are: *C. muticum*, $2n = 20$; *C. discolor*, $2n = 20$; *C. altissimum*, $2n = 18$. Extra chromosomes, possibly to be considered as accessories, were found in *C. muticum* and *C. discolor*. A Florida collection of *C. muticum* had the apparently triploid number $2n = 30$. The morphological and cytological evolution of the group is discussed.

Introduction

Cirsium muticum Michx., *C. discolor* (Muhl.) Spreng., and *C. altissimum* (L.) Spreng. are generally regarded as forming a natural group. Each species has an extensive range in eastern North America, a range in large part common to the three species. Petrak (8) placed the group in his section Onotrophe, subsection Acanthophylla, and indicated relative affinities by placing *C. muticum* alone in the series Mutica and *C. altissimum* and *C. discolor* together in the series Altissima. The closer relationship between the latter two species is seen also in the treatment of *discolor* as a variety of *C. altissimum* (as *Cnicus altissimus*) by Gray (4), a practice accepted by several other authors. Two other species, *C. filipendulum* Engelm. and *C. iowense* (Pammel) Fern., have also been variously regarded as species closely related to *C. altissimum* or treated as a variety or synonym of the latter. *Cirsium filipendulum* and *C. iowense* are species of limited range in the southwestern United States, apparently on the periphery of the range of *C. altissimum*. Since they do not occur in nor close to Canada, they have not been studied and no opinion is here expressed on their status.

Materials and Methods

Chromosome counts have been made from plants grown from seed collected with or removed from specimens in the herbarium of the Department of Agriculture, Ottawa (DAO). In addition, seed collections from the United States were kindly provided by Dr. R. K. Godfrey, Florida State University, and by Dr. W. S. Flory, The Blandy Experimental Farm, University of Virginia. In these two cases, plants grown at Ottawa have been preserved. Cytological techniques described by Frankton and Moore (3) have been followed.

Specimens from the following herbaria also have been examined and are included in the distribution maps: National Museum of Canada (CAN); Botany Department, University of Toronto (TRT); The University of

[1]Contribution No. 248.

British Columbia (UBC); The W. P. Fraser Memorial Herbarium, University of Saskatchewan (SASK); Museum National d'Histoire Naturelle, Laboratoire de Phanerogamie, Paris (P).

Cytology

The chromosome number $2n=20$ was reported by Ownbey (7) for *C. muticum* and *C. discolor* and for their interspecific hybrids. All these plants were collected in Minnesota. In the present study the following numbers were determined: *C. muticum*, $2n=20$, 22, 30, 31 (Figs. 1–3); *C. discolor*, $2n=20$, 21 (Fig. 4); *C. altissimum*, $2n=18$ (Fig. 5). As will be discussed further below, it is believed that one or two accessory chromosomes are found in populations of *C. muticum* and *C. discolor*.

Collections counted and their chromosome numbers were the following:

C. muticum Michx.—NEWFOUNDLAND: St. Anthony, Cremaillère Bay, Aug. 14, 1951, *Savile & Vaillancourt 2859* ($2n=22$). ONTARIO: Rondeau Park, 1948, *Frankton 662* ($2n=20$); Rainy River District, 15 mi N. of Rainy River, Aug. 21, 1948, *Dore 9139* ($2n=20$). MANITOBA: Riding Mountain National Park, 4 mi N. of Clear Lake, Aug. 15, 1948, *Rowe s.n.* ($2n=20$). UNITED STATES, FLORIDA: Wakulla Co., 6 mi NW. of Sopchoppy, on route 375, Sept. 19, 1959, *Godfrey 58935* (FSU), ($2n=30$ for five seedlings, $2n=31$ for one). MICHIGAN: ½ mi W. of Seney, Schoolcraft Co., Aug. 29, 1949, *Frankton, Senn & Dore 1113* ($2n=20$).

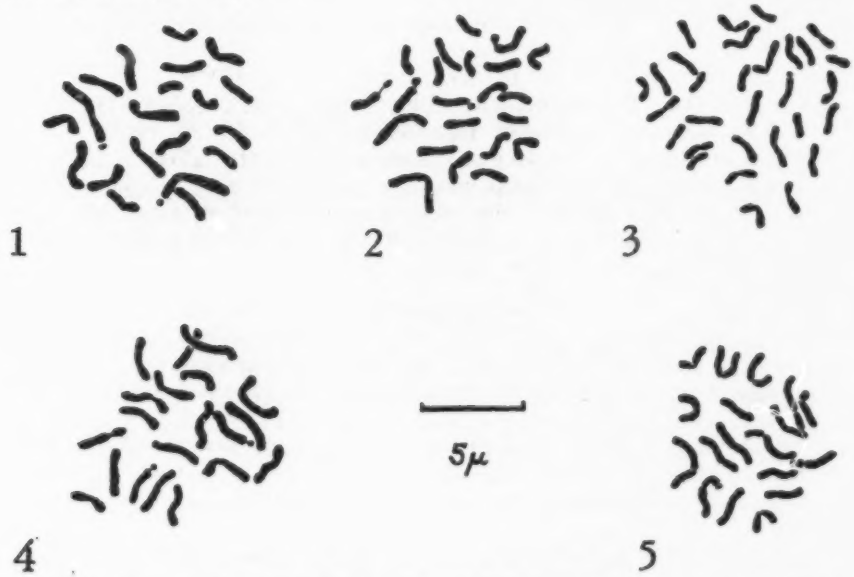

FIG. 1. Somatic chromosomes of *C. muticum* (*Rowe*) $2n=20$. FIG. 2. Somatic chromosomes of *C. muticum* (*Savile & Vaillancourt* 2859) $2n=22$. FIG. 3. Somatic chromosomes of *C. muticum* (*Godfrey* 58935) $2n=30$. FIG. 4. Somatic chromosomes of *C. discolor* (*Senn, Lindsay & Mulligan* 5056) $2n=20$. FIG. 5. Somatic chromosomes of *C. altissimum* (*Ownbey & Ownbey* 1259) $2n=18$.

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C. discolor (Muhl.) Spreng.—QUEBEC: 2 mi SE. of Ste. Anne de Bellevue, Oct. 30, 1949, *Mulligan 639* ($2n=20$). ONTARIO: Haliburton Co., 3 mi NE. of Minden, July 23, 1949, *Senn, Lindsay & Mulligan 5056* ($2n=20$). UNITED STATES, WISCONSIN: Arboretum, University of Wisconsin, Sept. 5, 1953, *Dore & Frankton 14741* ($2n=20$). VIRGINIA: near Winchester, Sept. 9, 1955, *Flory* ($2n=20$ for two seedlings, $2n=21$ for one).

C. altissimum (L.) Spreng.—UNITED STATES, MINNESOTA: Watonwan Co., 2.7 mi E. of St. James, Sept. 4, 1949, *Ownbey & Ownbey 1259* ($2n=18$). WISCONSIN: near Belleville, Sept. 6, 1953, *Dore 14768* ($2n=18$).

Measurements of the chromosomes and calculation of the total length of the karyome were made for two or three metaphase plates of each species and the results were averaged. The total chromatin length and the range in length of the individual chromosomes were: *C. muticum* ($2n=20$) total 47.3 μ, range 1.9 μ to 3.8 μ; *C. discolor* ($2n=20$) total 46.7 μ, range 1.8 μ to 3.3 μ; *C. altissimum* ($2n=18$) total 46.0 μ, range 1.8 μ to 3.5 μ.

Between the range extremes in each species there was a uniform gradation in lengths of the chromosomes. Allowance must be made for experimental error and for variation due to environmental factors in evaluating these data. It is believed that there is no significant difference between the total chromatin lengths of these species nor in the size ranges of the individual chromosomes. It is not claimed that the chromosomes are morphologically identical; probably translocations and rearrangements of small pieces have occurred in the evolution of the species, but these are not detectable in these measurements. Apparently the 18 chromosomes of *C. altissimum* contain the same amount of material as the 20 chromosomes of the other two species and the reduction in number may have been accomplished by the transfer of portions of two chromosomes to other surviving chromosomes.

In the case of the plant of *C. muticum* with the somatic number 22, the total chromosome length was 46.5 μ, the range in chromosome length, 1.2 to 3.3 μ. The two shortest chromosomes measured 1.2 μ, the next larger, 1.5 μ. It may be considered that the count $2n=22$ includes two accessory chromosomes and that these are the two shortest. No difference in staining was noted nor were they distinguished from the remainder of the set by a marked difference in size, as was seen in the case of the six accessory chromosomes reported in *C. acaule* (5). It seems preferable for the present to regard the numbers 21, 22, and 31 here reported as due to accessory chromosomes and to conclude that the number of regular somatic chromosomes of these species are *C. muticum*, 20; *C. discolor*, 20; *C. altissimum*, 18.

The number 30 found in the collection of *C. muticum* from Florida presents a special problem. This number is apparently triploid; the total chromosome length of the complement was 61.2 μ. From the above figure for diploid *C. muticum*, it is to be expected that the total length of a triploid set would be about 70 μ. The observed figure is reasonably close to expectation. The individual chromosomes ranged from 1.5 μ to 2.7 μ, a slight decrease in length from that of the diploid. The general size diminution may be a manifestation of the often observed loss of the gigas character of polyploids.

Morphology of the Species

Although these species are well known, complete descriptions with measurements of all floral organs are lacking. Since some of these characters bear on the phylogeny of this group, as well as on that of the genus as a whole, new descriptions have been prepared. Those for *C. muticum* and *C. discolor* have been made from the Canadian collections examined.

The three species can be separated by the following key.

Leaves densely white below, flower heads single at branch apex, involucral bracts spiny-tipped.
Cauline leaves deeply pinnatifid into narrow linear-lanceolate lobes; tips of inner phyllaries attenuate, narrow, not dilated..... *C. discolor* (Muhl.) Spreng.
Cauline leaves entire or subentire with shallowly sinuate lobes or rarely more deeply lobed, but the lobes then relatively broad (width at least 1/4 length); tips of inner phyllaries usually slightly dilated and erose..... *C. altissimum* (L.) Spreng.
Leaves only lightly pubescent below, flower heads single or 2–3 per branch; involucral bracts not spiny-tipped, with a minute prickle only..... *C. muticum* Michx.

Cirsium muticum Michx.

These plants reach 1.8 m (6 ft) in height and are loosely branched. Stems thin (to 1 cm) not fleshy, longitudinally ribbed, green, sparsely pilose with long, soft, multicellular hairs. Lower cauline leaves to 55 cm long, 20 cm broad, the upper leaves progressively smaller, outline ovate, pinnately lobed to 7/8 width of blade, lobes usually narrow, lanceolate-oblong, widely separated (especially in the upper leaves) the lobes forking or rather irregularly toothed and frequently asymmetrical, leaf angles and margins bearing fine spines, 3 mm or less; leaves green above, lightly pilose, lighter in color and more pubescent below, but not densely woolly. In this and the following species two types of hairs are found on leaf and stem: multicellular hairs and few-celled hairs. The multicellular hairs are relatively broad and consist of numerous short rather rectangular cells; few-celled hairs are thinner and apparently aseptate, but actually consist of one to two short basal cells and one very long slender cell. In *C. muticum*, the upper surface of the leaves bears few scattered multicellular hairs; the lower surface bears chiefly thin, tangled, few-celled hairs and relatively few multicellular hairs on the midrib. Flower heads one to three at apex of stem or branches, single or two or three in a cluster, one head terminal, the others on very short lateral branches, or sessile; heads to 2.5–3.5 cm high, width slightly more than half the height. Involucre bell-shaped, the base usually obtuse and rounded but sometimes cuneate, composed of about eight rows of phyllaries, only slightly imbricate, outer two rows of phyllaries short, the third about 6 mm long, 3–4 mm broad at base, ovate, the apex bearing a very short (at most .5 mm) prickle which is sometimes lacking and the tip merely thickened, the apical margin rarely minutely toothed, the outer surface dark-pigmented with a median well-developed glandular line, with long gray arachnoid hairs on margin and basal portion of surface, the amount varying from light (in var. *monticola*) to quite heavy; inner phyllaries longer, about 20 mm, narrower, linear-lanceolate, the terminal portion flat, thin, usually tapering and entire, occasionally very slightly dilated and the margin irregularly and minutely toothed, the apex pointed but not spine-tipped, usually twisted or curled. Corollas lavender to deep lavender, 16–30 mm long, proportionate to head size, more frequently in the

upper half of this range, tube (lower) portion 7–14 mm long (.4 to .45 times the corolla length), tube about .3 mm broad separated by a distinct shoulder from the throat and lobes which are about 1 mm broad, lobes 4–6 mm long; anthers, including appendages, 7–9 mm long, apex acute, filaments brown, sparsely covered with short hairs, to .1 mm long, style extruded to 5 mm, joint 4–5 mm from tip. Pappus grayish-white, 12–20 mm long, shorter than the corolla by 3–10 mm, consisting of 30–35 setae, the longer setae clavellate. Pollen 48–58 μ in diameter in polar view, variation within a sample 2–5 μ. Achenes 4.5–5.5 mm $\times$ 1.5 mm, dark brown, with yellow collar .3 mm deep at the apical end.

Representative specimens of *C. muticum* var. *muticum*. NEWFOUNDLAND: Blomidon Mts, Aug. 21, 1910, *Fernald & Wiegand 4196* (CAN); Labrador, Goose Bay, Traverspine River, Aug. 4, 1950, *Gillett & Findlay 5625* (DAO). NOVA SCOTIA: St. Paul Island, Aug. 11, 1953, *Erskine 53616* (DAO); Yarmouth Co., July 27, 1920, *Fernald, Bean & White 22921* (CAN). QUEBEC: 3 mi E. of Rupert House, Rupert River, 51°29′ N., 78°46′ W., Aug. 13, 1949, *Spafford 171* (DAO); Co. Brome, Bolton Pass, Aug. 9, 1942, *Marie-Victorin et al. 56235* (CAN); Saguenay Co., Brest, July 31, 1915, *St. John 90786* (CAN). ONTARIO: Cochrane District, Hearst, Aug. 3, 1952, *Baldwin & Breitung 3720* (CAN,TRT); Bruce Co., 11 mi NW. of Wiarton, July 21, 1949, *Senn et al. 4968* (DAO); Moose River, Renison, mile 156, Aug. 28, 1947, *Hustich & Tuomikoski 103* (CAN); Algoma District, Carp River, 47° N., 84°45′ W., Sept. 6, 1935, *Taylor et al. 1603* (TRT). MANITOBA: Cross Lake, 45 mi N. of L. Winnipeg, July 7, 1948, *Scoggan 3505* (CAN); 18 mi N. of Mafeking, Aug. 22, 1950, *Frankton 1228* (DAO). SASKATCHEWAN: 4 mi N. of McKague, Aug. 11, 1940, *Breitung 844* (DAO, CAN); Waskesiu, Aug. 22, 1938, without collector (SASK).

C. muticum var. *monticola* Fern.

Plants are shorter, 3–4.5 dm (12–18 in.) with three to five sessile heads in a very close cluster, heads smaller, to 2.5 cm high, involucre glabrate, the outer phyllaries less pubescent with only sparse marginal arachnoid pubescence; leaves to 15 cm long, 4 cm wide, lobed to about 4/5 width, leaves smaller, darker green, glabrate, lobes more regularly symmetrical than in the typical. The combination of the compact cluster of heads, reduced general pubescence, smaller size, and characteristic appearance of the leaves mark the variety.

This variety has been collected on mountains of the Gaspé Peninsula and Newfoundland. It may be questioned whether the more rigorous alpine environment is alone responsible for the characters of the variety or whether there is also a genetic basis. Specimens with a close cluster of heads are not restricted to this area.

Representative specimens of *C. muticum* var. *monticola*. NEWFOUNDLAND: Blomidon Mts., Aug. 21, 1910, *Fernald & Wiegand 4198* (CAN). QUEBEC: Gaspé, Table Top Mt., Aug. 12, 1906, *Fernald & Collins 262* (CAN); Gaspé, Mt. Albert, July 19, 1940, *Scoggan 1653* (CAN); Mt. Albert, Aug. 8, 1923, *Marie-Victorin et al. 17528* (DAO).

The apparently triploid *C. muticum* from Florida (*Godfrey 58935*) matches closely the characters of this species and it does not seem possible to refer it elsewhere. The collector recorded that the plant from which the seed was taken was 1.8 m tall, flowers lavender-pink, growing in a boggy area bordering a swamp. Five seedlings were raised in field plots at Ottawa. These reached heights of about 1 m under the drier conditions. Heads measured 3.5 cm high, 1 cm wide, rather narrower than is usual; corolla 24 mm long, tube 9 mm, lobes 6 mm, anthers 10 mm, pollen 55-61 μ, pappus of 50–60 setae. The plants differ from the above description of *C. muticum* only in that the anthers and pollen are slightly larger and that the pappus contains more setae. An attempt was made to study meiosis in one of the plants. Material was poor, but so far as could be determined, it seemed that 15 bodies, presumably bivalents, were regularly present at metaphase I. A bagged head set seed, demonstrating self-fertility. These observations indicate that the plant is acting as a normal diploid, whatever its origin. Possibly it should be recognized as a new species. An extensive cytotaxonomic survey of *C. muticum* in the region from which this plant was collected is required to explain adequately the nature of the population. The seedling with the additional chromosome ($2n = 31$) differed from the others in a distinctly slower growth rate, thicker and more glossy leaves, and a much-branched bushy habit which seemed due to the loss of apical dominance in the main stem. The additional chromosome is presumably responsible for the variant characters. For this reason, the additional chromosome in this case should probably not be called an accessory, since these bodies usually exert no phenotypic influence. Rather may it be an extra chromosome resulting from meiotic irregularities.

Cirsium discolor (Muhl.) Spreng.

This species is 1–2 m (3–6 ft) tall, in habit open and freely branched above, stems thin, firm, ridged, green or greenish-brown, lightly pilose with mainly multicellular hairs and fewer aseptate hairs intermixed. Lower cauline leaves as much as 50 cm long, 25 cm broad, in outline elliptic, broadest at middle, deeply lobed, to 9/10 width of blade, lobes remote, narrow oblong, sometimes forked, lobing often asymmetrical, the margins and apices bearing few very fine 1–3 mm spines; upper cauline leaves progressively smaller but of similar form. On the whole, leaf segments are so narrow and remote that the amount of green tissue is small. Leaves green above, lightly pilose with short multicellular hairs and a light covering of narrow arachnoid few-celled hairs; white, densely woolly below with chiefly narrow few-celled hairs. Flower heads always single at stem apex, never with several heads in a close cluster; heads 3.5 cm high, 2–2.5 cm wide, rarely 4 cm high; involucre campanulate, base obtuse-rounded, of about eight rows of phyllaries, the outer five spiny-tipped, inner two rows unarmed, one row transitional. Outer phyllaries broadly lanceolate, imbricate, those of outer two rows short, those of the third row about 8 mm long, 3 mm broad at base, with strong glandular ridge, surface glabrous but with long thin gray hairs on the margin, especially near the base of the phyllary, terminated by slender recurved 5–6 mm spines; inner phyllaries longer, to 3 cm, membranous, tapering to a flexible point, tip not dilated, margin entire, usually curled. Corollas pink lavender, 25–32 mm long, tube 12–16 mm

long (.45–.55 times the corolla length), lobes 6–9 mm, varying by 1–2 mm on a single floret, tube diameter .3 mm, throat diameter 1 mm; anthers 8–10 mm long, tips narrow, acute, filaments brown, hairs to about .2 mm and more abundant than in *C. muticum*, style extruded to 5 mm, joint 5–6 mm from tip. Pappus white, 18–25 mm long, 5–8 mm shorter than corolla, of 50–60 setae, the longer setae clavellate. Pollen 51–56 μ in diameter in polar view. Achenes 4–5 mm × 1.2–1.7 mm, light brown with some darker striae, yellow collar .5–.75 mm at upper end.

The self-compatibility of one plant from the Virginia seed collection was tested; this plant was self-fertile when heads were bagged.

Representative specimens of *C. discolor*. QUEBEC: Comte des Deux-Montagnes, La Trappe, Sept. 4, 1956, *P. Louis-Marie* (DAO, UBC); Chambly Co., Chambly, Sept. 6, 1932, *Fr. Cleonique 4500* (DAO); Rouville Co., Rougemont, Sept. 17, 1956, *L. Cinq-Mars s.n.* (DAO). ONTARIO: Queenston Heights, Sept. 5, 1896, *Scott 14391* (CAN); Haldimand Co., 3 mi SE. of Dunnville, Aug. 17, 1951, *Miller 607* (TRT); Lambton Co., Walpole Is., July 24, 1948, *Frankton, Bassett & Dore 733* (DAO); Stormont Co., 3 mi W. of Cornwall, Aug. 26, 1953, *Gillett 7953* (DAO). MANITOBA: Emerson, Aug. 15, 1922, *Groh s.n.* (DAO).

Cirsium altissimum (L.) Spreng.

This species has many characters in common with *C. discolor* and the following description is confined almost entirely to the features by which *C. altissimum* differs from its congener.

Cirsium altissimum is a taller plant, reaching heights up to 4 m (12 ft) but of a similar open branched habit. Leaves are entire or subentire, lower cauline leaves usually lobed to a greater degree than the upper, oblong-ovate or elliptic, shallowly sinuate lobed or undulate-pinnatifid, less commonly lobed to half the width of the blade, in which case the lobes are similar in form to those of *C. discolor* but are much broader. Primarily the species are separated by the entire or much less divided character of the leaves of *C. altissimum*.

The flower heads are similar in size, shape, and involucral characters with the exception of the inner two rows of phyllaries which differ slightly in the nature of their tips. In *C. altissimum* the tips are frequently expanded to a slight degree and finely erose, a character very rarely seen in *C. discolor*.

The flowers are similar in both species; those of the collections of *C. altissimum* examined were 22–32 mm (25–30 mm) long, tube 10–15 mm long (.48–.52 times the length of the corolla), lobes 6–8 mm; tube .3 mm in diameter, throat about 1 mm broad; anthers 7.5–10 mm, filaments brown and rather densely covered with hairs up to .2 mm long, style extruded to 5 mm, joint 5–6 mm from tip. Pappus about 5 mm shorter than corolla, of 50–60 setae. Pollen 50–60 μ in diameter. Achenes 4.5–5 mm × 1.8–2 mm, straw to brownish with few purplish striae, .8 mm yellow band at the upper end.

Since this species has not been found in Canada it has been studied less extensively and the range of variation is known less well. A relatively few specimens from Minnesota, Wisconsin, Illinois, Kansas, West Virginia, and North Carolina have been examined. Most of these bore leaves that were entire

or shallowly lobed, a few had leaves more deeply pinnatifid and approaching *C. discolor* in this character. Of the two collections whose chromosome number is reported, one (*Ownbey & Ownbey 1259*) had entire leaves, the second (*Dore 14768*) bore lobed leaves and was the closest of all the specimens to *C. discolor*. Both collections had the same chromosome number and differed in this from *C. discolor*.

Distribution

Cirsium muticum is found in moist organic habitats—low woods and swamps. Canadian distribution is shown in Fig. 6. The species is common in all eastern provinces and as far west as central Saskatchewan. It is known as far north as 54° in Labrador and in Manitoba and generally follows the forest area. According to the literature, the species extends in the United States along the entire east coast and west to Louisiana. The most western record in the United States is from Turtle Mountains, North Dakota (7). It seems probable that in postglacial time the species has entered Canada east of the Great Lakes and has spread northwest across Ontario to northern Saskatchewan. Continued spread in the forest area of the northern Prairie Provinces may be anticipated.

A white-flowered form of *C. muticum*, *f. lactiflorum* Fern., was described from Newfoundland. Specimens from this province, from Matapedia Co., Quebec, and Wallwort, Saskatchewan, have been seen. The gene has spread through the entire species range, or has arisen at several points. Specimens referable to the form *subpinnatifidum* (Britt.) Fern., characterized by glabrous and shallowly lobed leaves have been seen from Newfoundland and from western Quebec. Of one of these it was noted that the plant was in deep shade. It seems possible that the reduced segmentation may be an environmental effect.

Cirsium discolor is found in more mesophytic areas, in thickets, prairies, and better-drained soils, than is *C. muticum*. In Canada, *C. discolor* is known only from the settled areas of southern Ontario and southwestern Quebec and from one locality in southern Manitoba (Fig. 7). The white-flowered form, *f. albiflorum* House, has not been seen in Canada.

The range of this species and of *C. altissimum* in the United States is known to the authors only from the literature and some inconsistencies have been noted. The southern and western limits as here stated may not be exact and are included to give a general picture of the distribution of these species.

In the eastern United States, *C. discolor* is found in New England, south to Georgia and roughly northwest to Tennessee, Missouri, and Minnesota. Although *C. muticum* also is found in this general area, the species are separated by habitat preferences, as Ownbey (7) has described, and only the single occurrence of natural hybridization reported by him is known.

Cirsium altissimum seems to occupy habitats similar to those in which *C. discolor* is found and also is widespread in the eastern United States. It approaches Canada in Michigan and southern New York (2) and its occurrence on Kelley's Island, Ohio (1), in the western end of Lake Erie, is the most northerly location known. Early reports of *C. altissimum* in Canada, unsupported by collection records, are regarded as highly doubtful, possibly

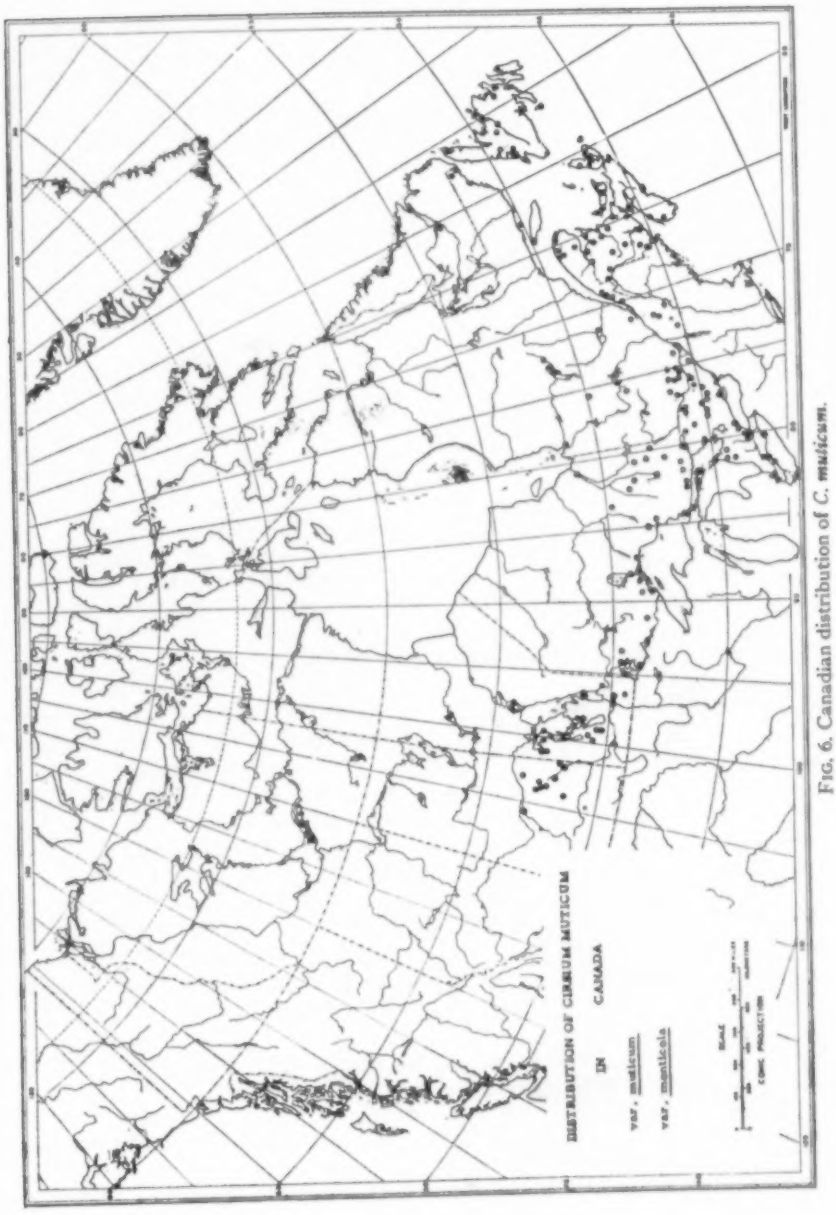

FIG. 6. Canadian distribution of *C. muticum*.

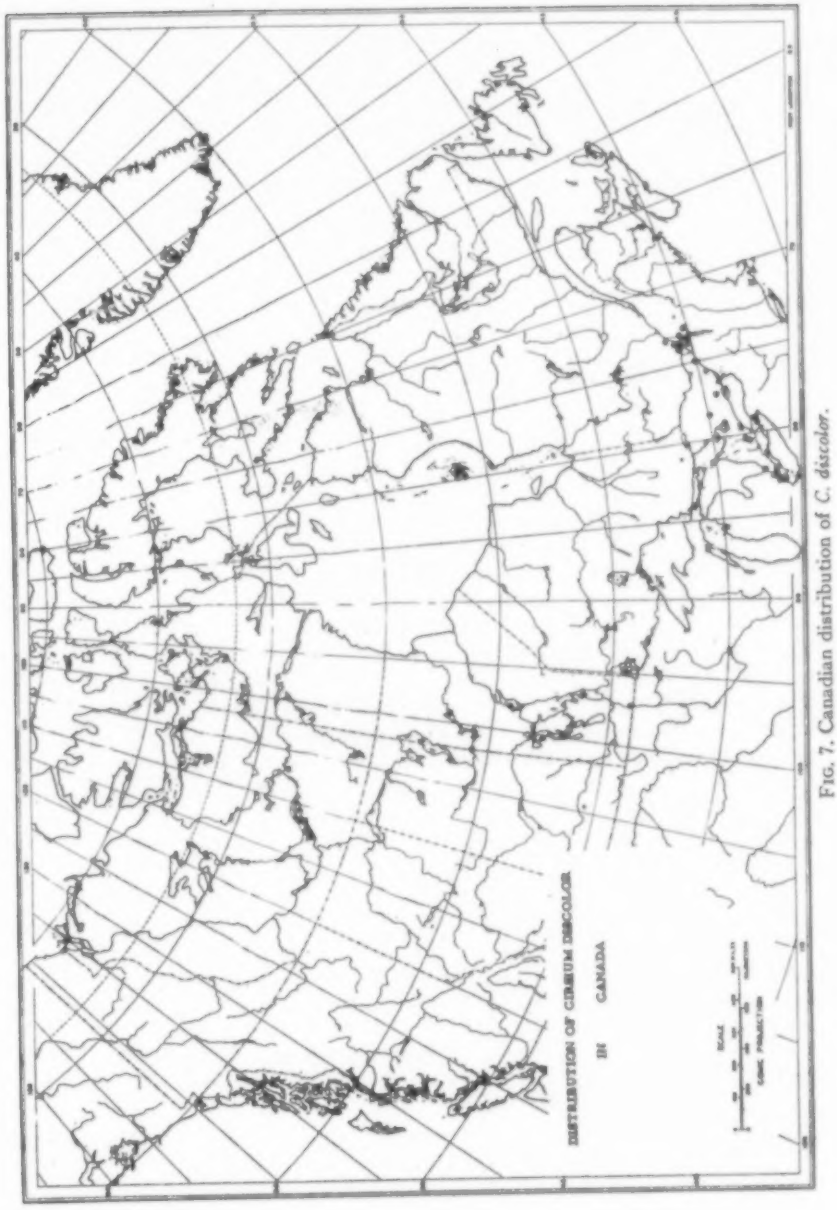

FIG. 7. Canadian distribution of *C. discolor*.

referring to *C. discolor*. From the area of the Great Lakes the species extends to the Gulf of Mexico, west to Texas, and north to the Dakotas. The range is somewhat larger and more southerly than that of *C. discolor*. The species are sympatric except in the far north, where *C. discolor* alone is present, and in the extreme south, where only *C. altissimum* occurs.

Discussion

There can be no doubt that, on morphological grounds, *C. discolor* and *C. altissimum* are more closely related to each other than to *C. muticum*. This is seen in the fact that they are alike in the following characters by which they differ from *C. muticum:* Flower heads borne singly, rather than in a cluster, as in *C. muticum;* leaves densely woolly below, rather than lightly hairy; involucral bracts spiny-tipped, as opposed to non-spiny; corolla length 25–32 mm, tube/corolla ratio .45–.55 as opposed to 16–30 mm, ratio .4–.45; number of pappus setae 50–60 rather than 30–35. Known chromosome numbers, however, point to a closer affinity between *C. discolor* and *C. muticum* than between *C. discolor* and *C. altissimum*. To arrive at an understanding of the phylogeny of the species it is necessary to harmonize these data and to consider as well the geographical ranges. The disagreement here between morphological and cytological criteria indicates that morphological and cytological evolution have proceeded independently.

Criteria by which morphological evolution in *Cirsium* may be evaluated were discussed by Moore and Frankton (6) in connection with two species of western Canada. Following the same criteria, it must be concluded that *C. discolor* and *C. altissimum* are morphologically more advanced than *C. muticum*. This conclusion follows from the greater number of pappus setae and the greater length of the tube portion of the corolla relative to the length of the entire corolla. The amount of morphologic advance is, however, slight.

The authors (3) have expressed the opinion that the chromosome number $x=17$ is basic to the genus *Cirsium* and that among certain North American species cytological evolution has progressed by a reduction in number which has taken place by translocation of chromosome material. In addition to the ancestral and worldwide haploid number 17, the haploid numbers 13, 12, 11, 10, and 9 are now known. Measurements of the total chromosome length in species of somatic numbers 34, 26, and 22 showed that the total length was approximately the same, about 45 μ (3). This figure is in close agreement with the tota chromosome length (46–47 μ) here reported for *C. muticum*, *C. discolor*, and *C. altissimum*. Although the present group of species is not closely related to those previously studied (*C. undulatum*, *C. flodmanii*) it appears that the same process of cytological evolution has operated in both.

The range in chromosome lengths in the complements of the present three species of somatic numbers 18 and 20 is approximately 1.8–3.5 μ, as compared with 1.2–2.3 μ (*C. undulatum*, $2n=26$) and 1.4–2.6 μ (*C. flodmanii*, $2n=22$). These figures agree with expectation that the range in lengths of the complements will broaden as the number of chromosomes is reduced, the total amount of chromatin remaining constant. Distribution of translocated segments appears to be random, resulting in increases in length of both the short and the long chromosomes.

Distribution, chromosome number, and morphology are consistent with the hypothesis that *C. muticum* is the most primitive of the three species and most closely resembles the ancestor of the group. The morphological changes to the characters shared by *C. discolor* and *C. altissimum* have occurred without change in chromosome number, as shown by *C. discolor*. Further cytological evolution has taken place in the development of *C. altissimum* and this may or may not be responsible for the morphological differences which separate the latter from *C. discolor*. This most recent cytological change, the reduction in chromosome number from 20 to 18, may indeed have resulted in the additional plasticity which produced the southern phenotypes which are sometimes recognized as species distinct from *C. altissimum*. It appears that the latter is better adapted to a southwards spread than its congeners and may have less cold-hardiness. It is believed to be the most recently evolved species of the three.

The chromosome numbers of a considerable number of *Cirsium* species of both the New and the Old World are now known and reports of accessory chromosomes are not common. Probably the genus is not one of those in which accessories are frequent. The occurrence therefore of extra chromosomes in 3 of the 19 plants counted in this study seems a rather high frequency. Whether these are to be classed as accessory chromosomes has been discussed and in one case it seems preferable to regard the additional body as an extra normal chromosome. The occurrence of "extras" and the existence of a plant of *C. muticum* with an apparently triploid number suggests that a condition of cytological instability may still exist within this group of three species and numbers other than those here reported may be found. The group is an interesting one and extensive cytological sampling by those in a favorable geographic position may be rewarding.

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